E246 Electronics & Instrumentation

Lecture 1: Introduction and Review of Basic Electronics

Course Personnel

- Instructor:

  Yi Guo

  Office: Burchard 207

  Office Hours: Tuesday & Thursday 2-3pm

  Ph: (201) 216-5658

  Email: yguo1@stevens.edu

Textbook

Essentials of Electrical and Computer Engineering, by David V. Kerns and J. David Irwin, Pearson Prentice Hall., ISBN 0-13-923970-7, 2004.

Reference Books

R. C. Dorf and J. A. Svoboda, *Introduction to Electric Circuits*, 6/e, John Wiley & Sons, 2004.

J. W. Nilsson and S. A. Riedel, *Electric Circuits*, 6/e, Prentice Hall, 2000.

G. Rizzoni, *Principles and Applications of Electrical Engineering*, 3/e, McGraw Hill, 2000.

Reference Books

- Allan R. Hambley, Electronics, 2nd Ed. Prentice Hall, 2000
- Smith and Dorf, Circuits, Devices and Systems, 5th Ed. John Wiley & Sons, 1992.
- Bobrow, Fundamentals of Electrical Engineering, 2nd Ed. Oxford University Press, 1994.
- Horowitz and Hill, The Art of Electronics, 2nd Ed. Cambridge University Press, 1989.

Today’s Plan

- Introduction to Electrical Engineering
- Electric circuit variables
- Electric circuit elements: resistor, independent and dependent sources, voltmeters and ammeters, switches
- Kirchhoff’s Law
- Sections in textbook: 1.1~1.2,2.1~2.3

The Subject

- *Electrical engineering* is the profession concerned with systems that produce, transmit, and measure electric signals.
- It combines the physicist’s models of natural phenomena with the mathematician’s tools for manipulating those models to produce systems that meet practical needs.

Five Major Classifications of Electrical Systems

- Communication systems
- Computer systems
- Control systems
- Power systems
- Signal-processing systems

Circuit Theory

- An electric circuit is a *mathematical model* that approximates the behavior of an actual electrical system.
- The models, the mathematical techniques, and the language of circuit theory will form the intellectual framework for your future engineering endeavors.

Problem Solving Process

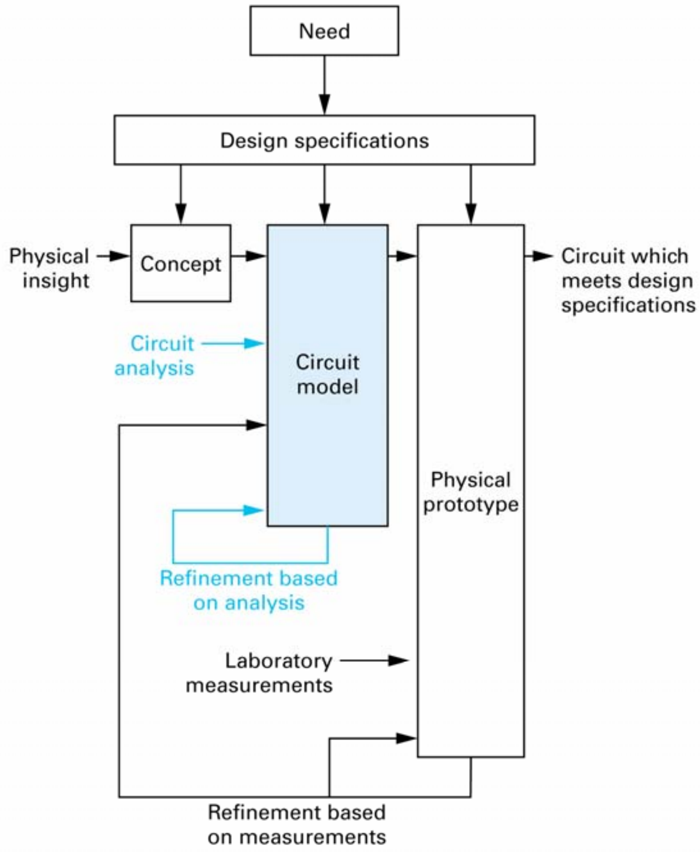


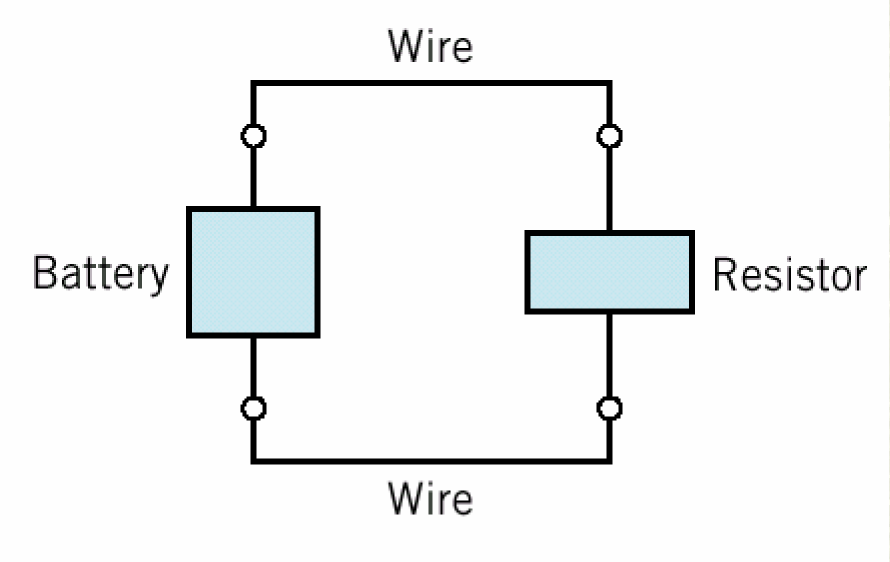
Figure 1.4 A conceptual model for electrical engineering design

From: Nilsson/Riedel, Electric Circuits, 6e, July 2000 Prentice Hall, Inc.

What is Electric Circuit?

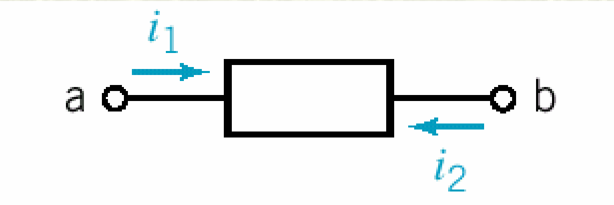
- An electric circuit is an interconnection of *electrical elements* linked together in a *closed* path so that an *electric current* may flow continuously.

A simple circuit:



Basic Circuit Variables

- **Charge**: the quantity of electricity responsible for electric phenomena, denoted by q, Unit: Coulomb, C.
- **Current**: the time rate of flow of electric charge past a given point, denoted by i.
  - Mathematical representation: $$i = \frac{dq}{dt}$$
  - Unit: ampere, A.

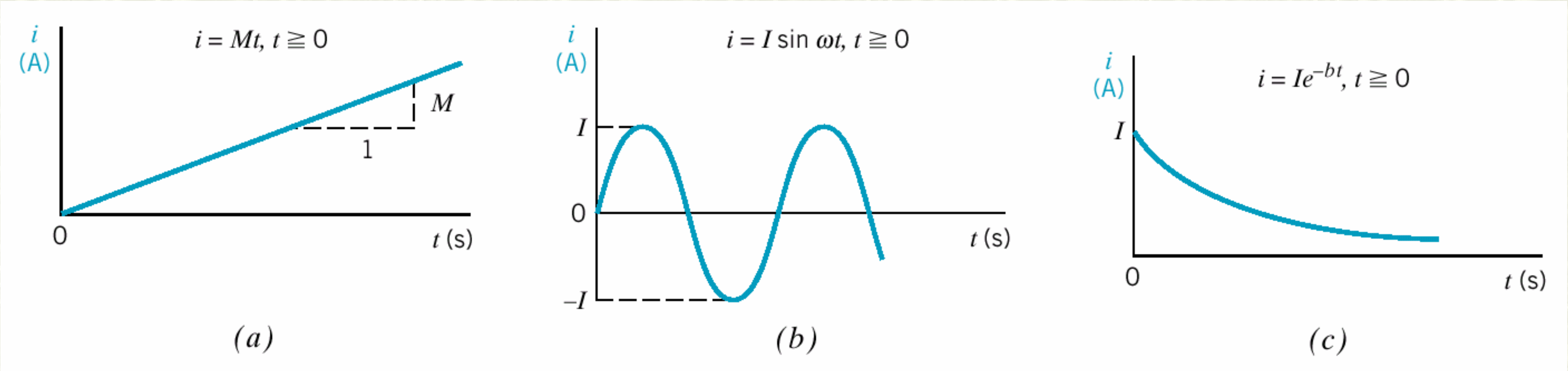


Current

- Two different types:
  - DC (direct current) is a current of *constant magnitude*

  - AC (alternating current is a time-varying current *i(t)* that has a sinusoidal form).

Time-Varying Current

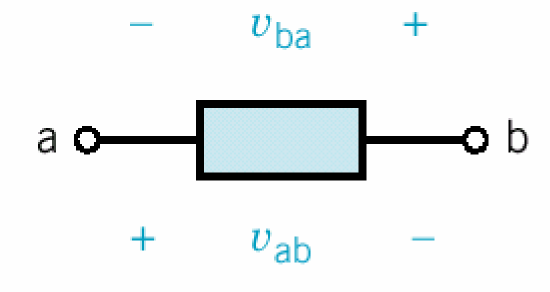


(a) A ramp with a slope *M*.
(b) A sinusoid.
(c) An exponential. *I* is a constant. The current *i* is zero for $t < 0$.

Voltage

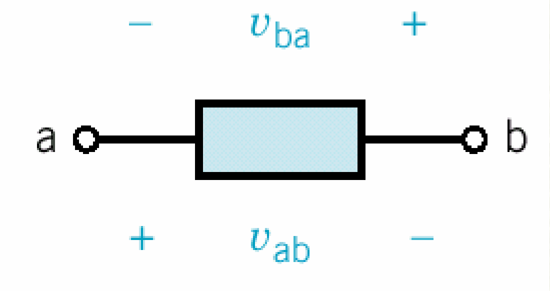
- Definition: energy required to move a unit positive charge from the – terminal to the + terminal across an element.
- Mathematical representation:

$$v = \frac{dw}{dq}$$



- Unit: volt, V.

Voltage



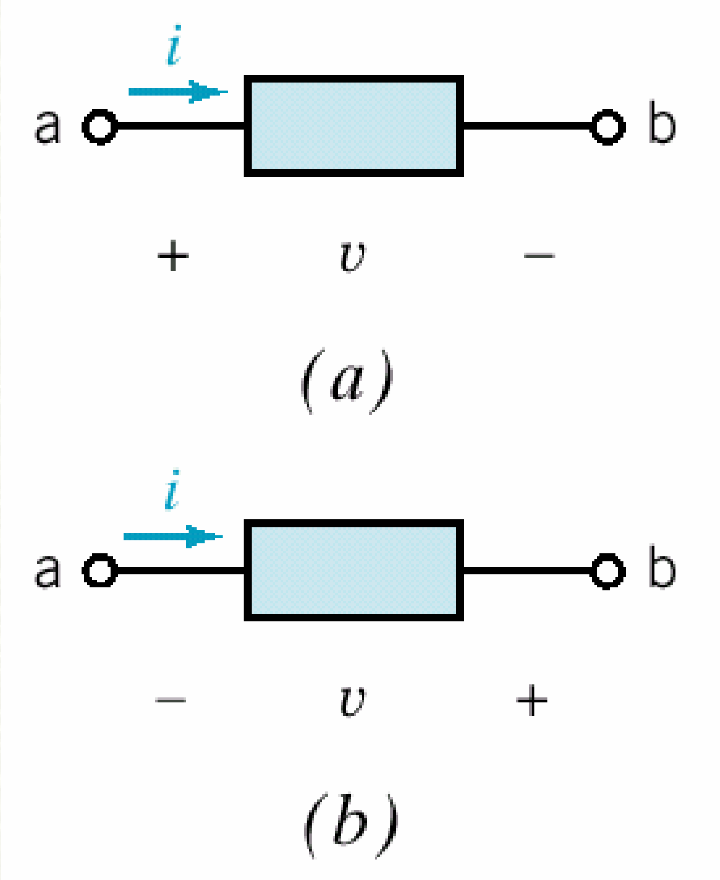
- The direction of a voltage is given by its polarities:
  - The voltage v_{ab} is proportional to the work required to move a positive charge from terminal a to terminal b.
  - The voltage v_{ba} is proportional to the work required to move a positive charge from terminal b to terminal a.
- v_{ab} is read as "the voltage at terminal a with respect to terminal b"; or, "the voltage drop from terminal a to terminal b".

$$v_{ab} = -v_{ba}$$

Power

- Definition: time rate of expending or absorbing energy.
- Mathematical representation: $p = \frac{dw}{dt}$
- Unit: watt, W.
- Relation with current and voltage:

$$p = vi$$



Passive convention: the assigned direction of the current is directed from the + terminal to the – terminal.

a). Power *absorbed* (or *dissipated*) by the element, as *v* and *i* adhere to the passive convention.

b). Power *supplied* (or *delivered*) by the element, as *v* and *i* do not adhere to the passive convention.

Concepts

- A **linear** elements satisfies the property of *superposition* and *homogeneity*.

IF $i_1 \rightarrow v_1$

$i_2 \rightarrow v_2$

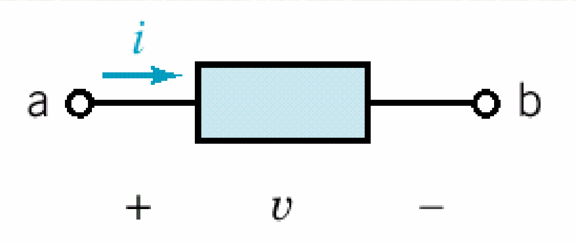
THEN $i_1 + i_2 \rightarrow v_1 + v_2$

$ki_1 \rightarrow kv_1$

$ki_2 \rightarrow kv_2$

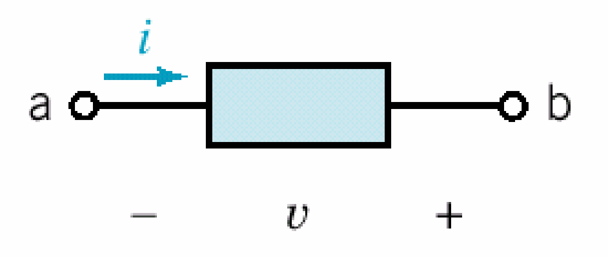
- A **passive** element *absorbs* energy.

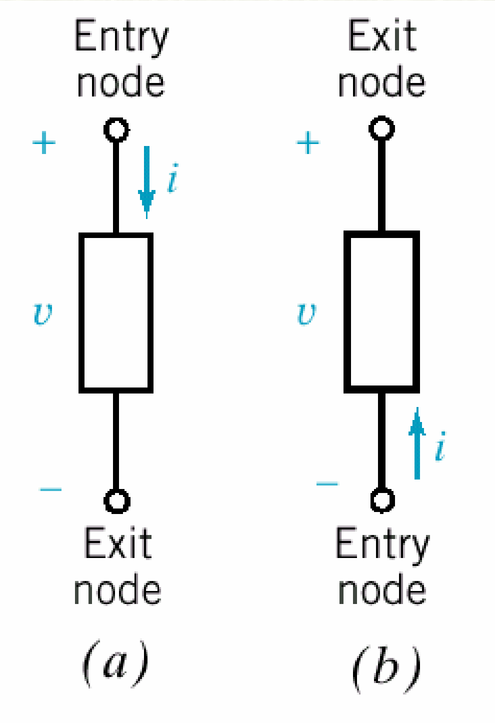
$$w = \int_{-\infty}^{t} vi\,d\tau \geq 0 \quad \text{for all } t.$$



- An **active** element is capable of *supplying* energy.

$$w = \int_{-\infty}^{t} vi\,d\tau > 0 \quad \text{for at least one } t.$$





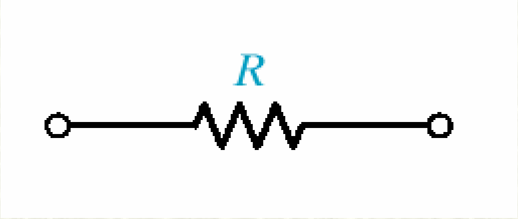
(a) The entry node of the current *i* is the positive node of the voltage *v*,

(b) the entry node of the current *i* is the negative node of the voltage *v*. The current flows from the entry node to the exit node.

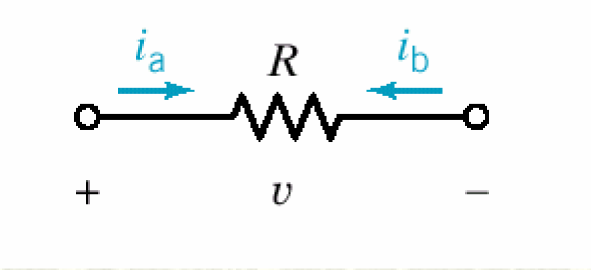
Resistors

- Resistors impedes the flow of current.

  Unit: Ohm.



- Ohm's law: ***v=Ri***



$v=Ri_a$

$v=-Ri_b$

- Power delivered to a resistor:

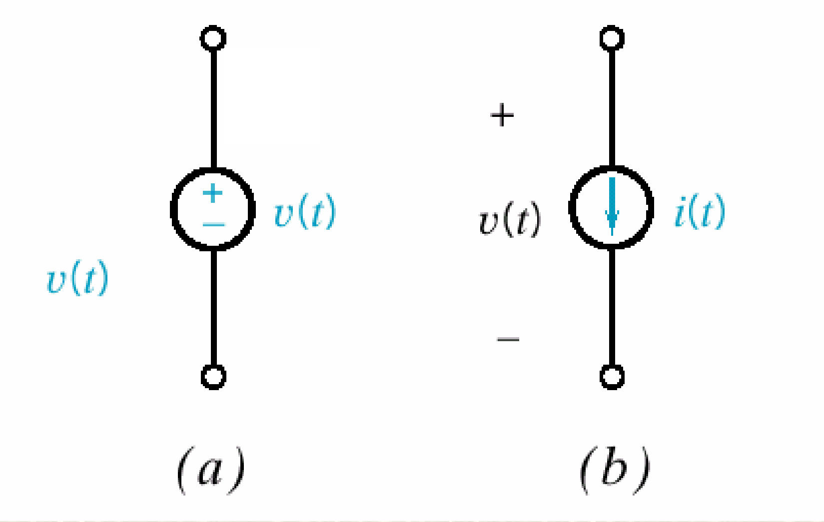
$$p = vi = v(v/R) = v^2/R$$

$$p = vi = (iR)i = i^2R$$

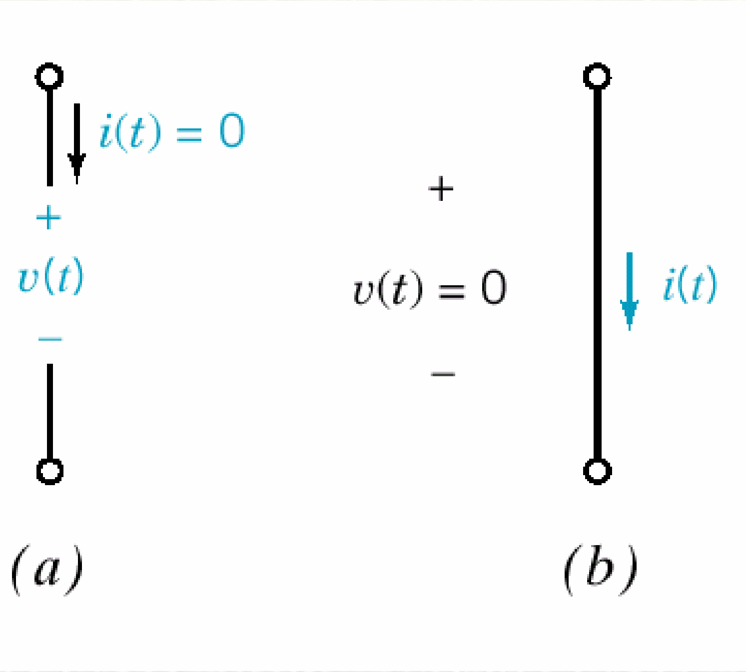
Independent Sources

- *Sources*: voltage or current generator capable of supplying energy to a circuit.
- *Independent* sources: sources not dependent on other circuit variables.

(a) Ideal voltage source, denoted by *v(t);*
(b) Ideal current source, denoted by *i(t).*



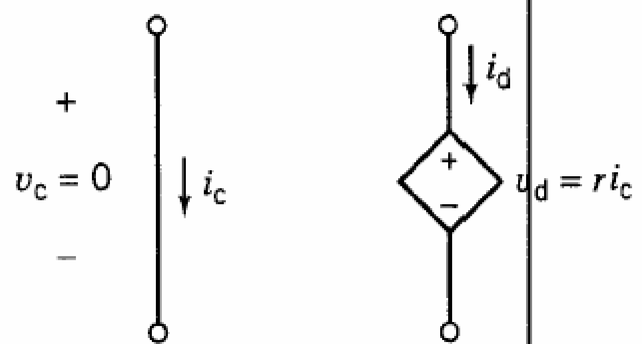
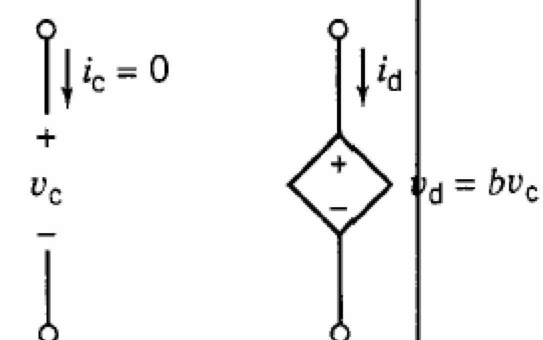
(*a*) Open circuit: an ideal current source having *i(t)*=0;
(*b*) Short circuit: an ideal voltage source having *v(t)*=0.



Dependent Sources

- They depend on another circuit variables.

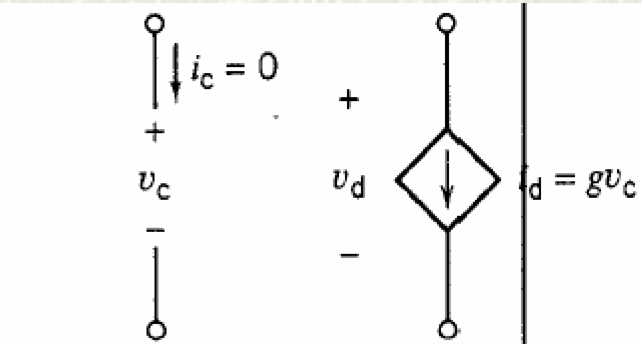
Table 2.8-1 **Dependent Sources**

Description	Symbol
Current-Controlled Voltage Source (CCVS) r is the gain of the CCVS. r has units of volt/ampere.	
Voltage-Controlled Voltage Source (VCVS) b is the gain of the VCVS. b has units of volts/volt.	

Voltage-Controlled Current Source (VCCS)

g is the gain of the VCCS.

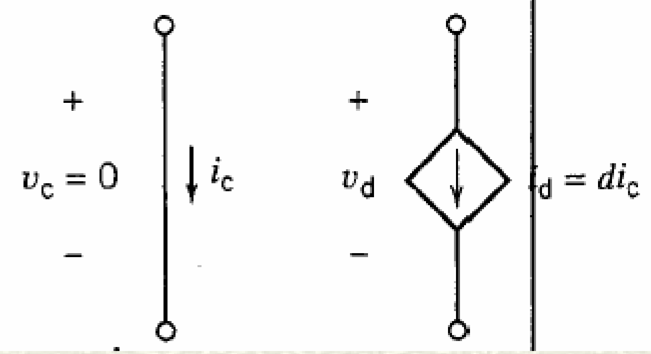
g has units of amperes/volt.



Current-Controlled Current Source (CCCS)

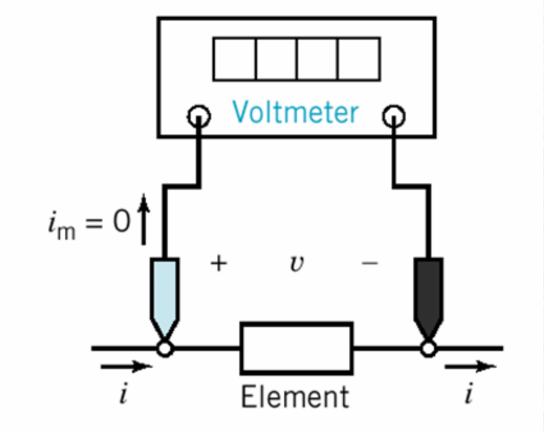
d is the gain of the CCCS.

d has units of amperes/ampere.



Voltmeters

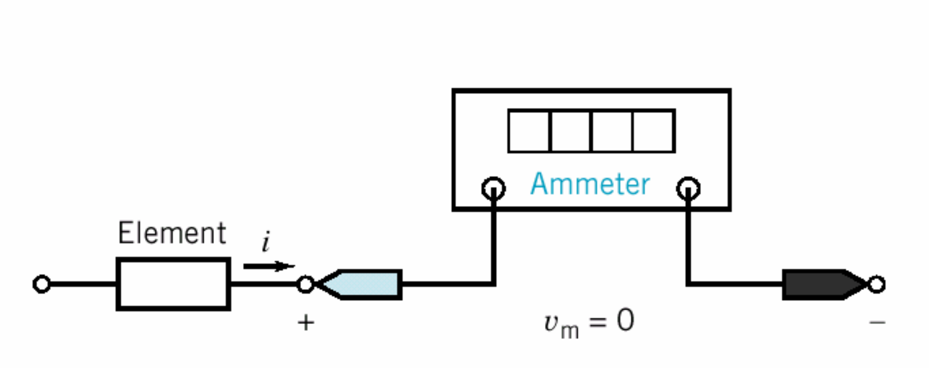
- An ideal voltmeter measures the voltage *across* its terminals.



It has the terminal current $i_m = 0$.

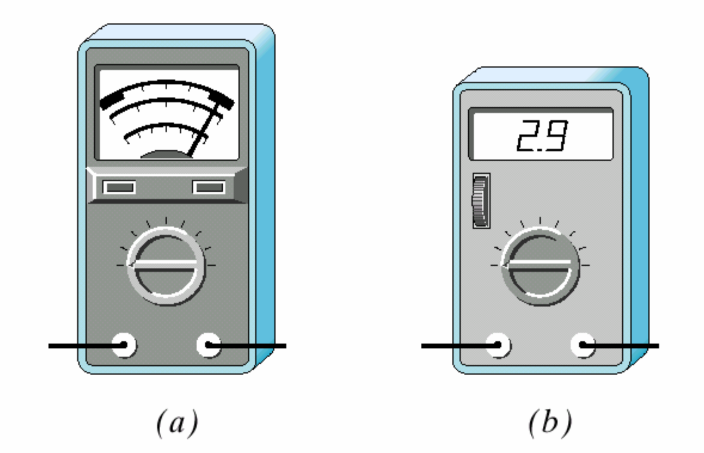
Ammeters

- An ideal ammeter measures the current *flowing through* its terminals.



It has zero voltage across the terminals: $v_m = 0$.

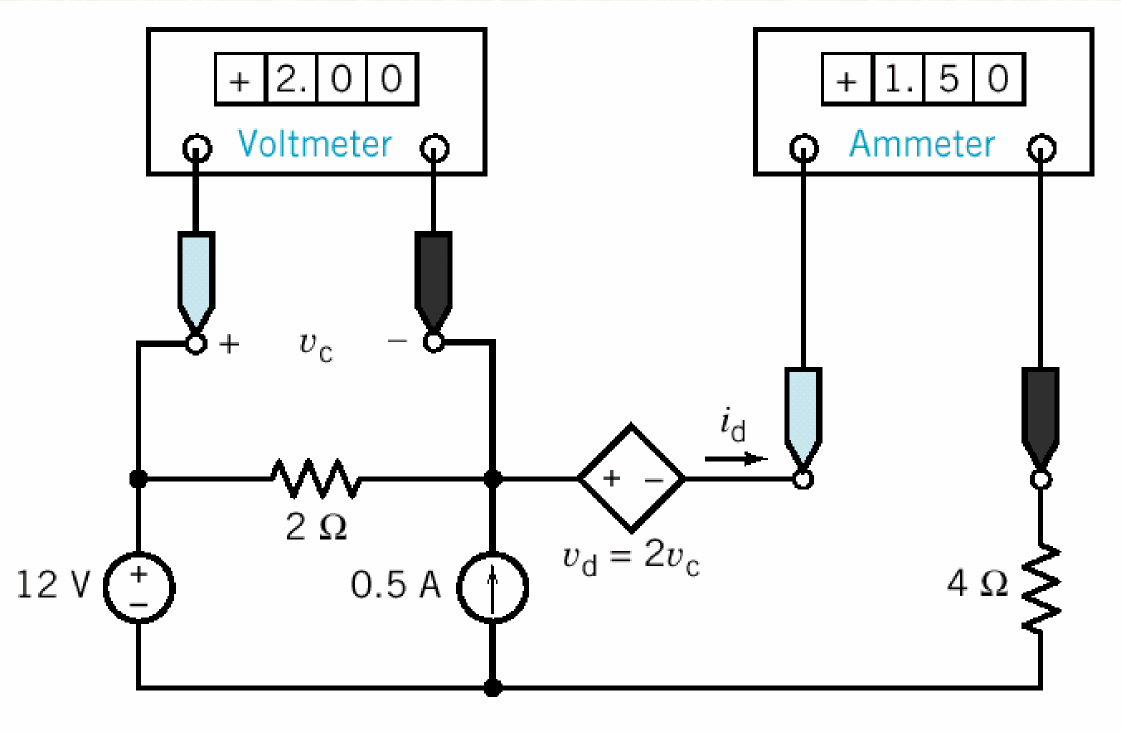
Voltmeters and Ammeters



Analog and digital meters.

Probes are color coded: red terminal is the positive terminal, black terminal is the negative terminal.

Example:

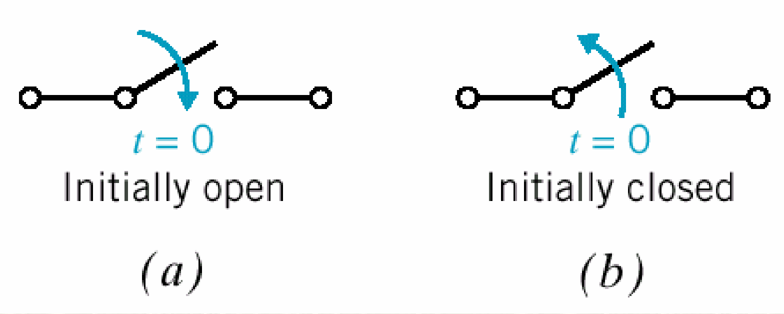


A circuit containing a VCVS. The meters indicate that the voltage of the controlling element is $v_c = 2.0$ volts and that the current of the controlled element is $i_d = 1.5$ amperes.

Determine the power absorbed by the VCVS.

Switches

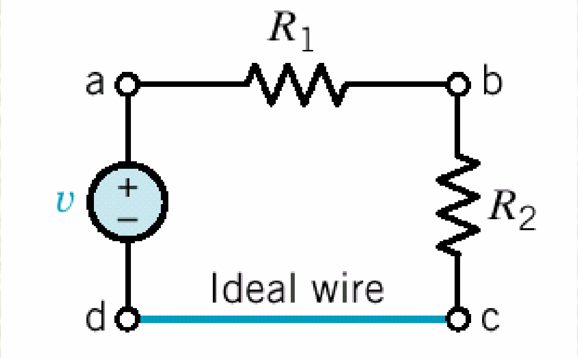
- Single-Pole Single-Throw switch:



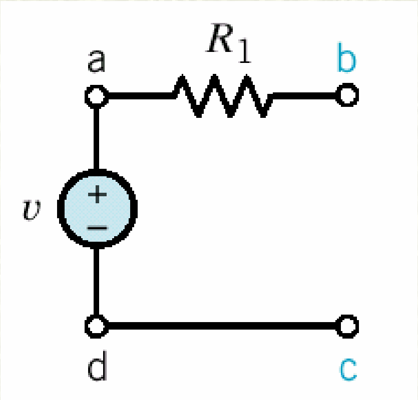
Two distinct states: *open* and *closed*.

Kirchhoff’s Law

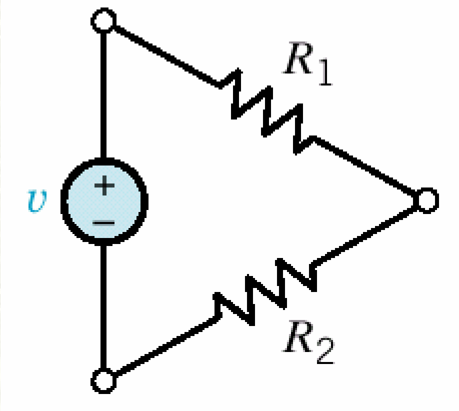
- We consider circuits made up of resistors.
- We assume *ideal wires*, whose model has zero resistance.



- We call it an *open circuit* at terminal b-c

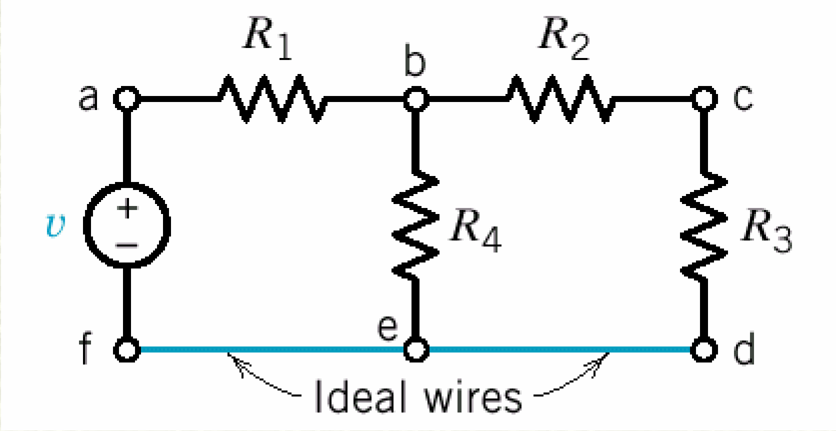


- *Node*: A junction in which two or more elements have a common connections, or, a junction of conductors composed of idea wires.



How many nodes in the above figure?

- *Closed path (loop)*: A traversal through a series of nodes ending at the starting node without encountering a node more than once.



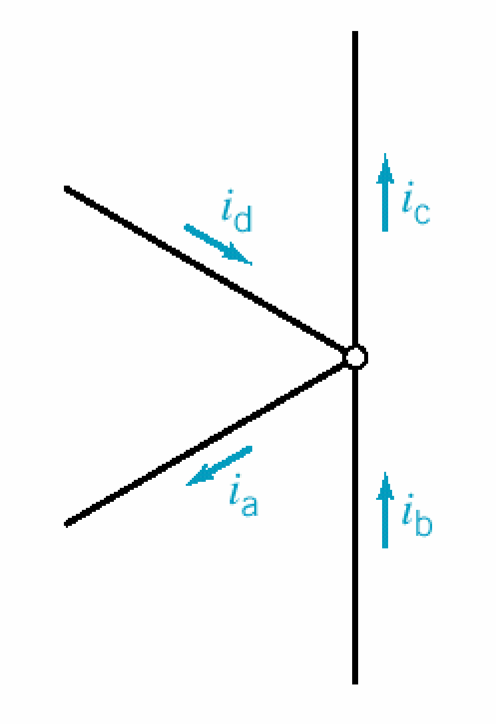
How many loops in the above figure?

Kirchhoff's Current Law

The algebraic sum of the currents into a node at any instant is zero.

i.e. *the sum of currents entering the node is equal to the sum of currents leaving the node.*

Reason: Charge cannot accumulate at a node, as node is a perfect conductor.



$$i_b + i_d = i_a + i_c$$

If assuming entering is positive,

$$-i_a + i_b - i_c + i_d = 0$$

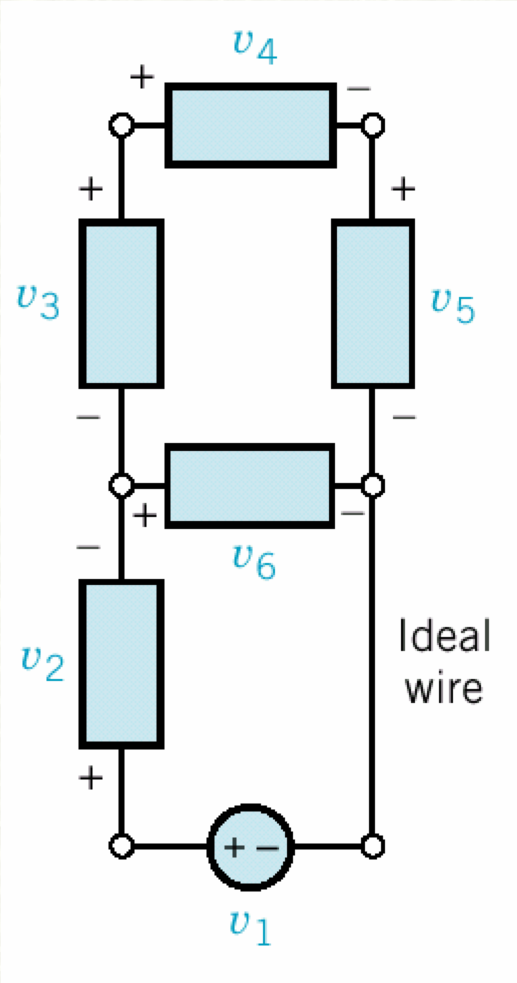
Kirchhoff's Voltage Law

The algebraic sum of the voltages around any closed path in a circuit is zero for all time.

i.e. *the voltage rise is equal to the voltage drop in the tracing direction around a closed path.*

Reason: Recall that the voltage is work per unit charge.A circuit loop is a conservative system, and the energy required to move a charge around a closed path is zero.

- Assign an algebraic sign (reference direction) to each voltage in the loop
- A common convention is to use the voltage sign on the first terminal of an element encountered as we traverse a path.



$$-v_6 - v_3 + v_4 + v_5 = 0$$